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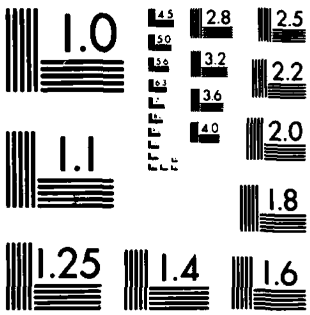
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DOCUMENT 310-86

(12)

TEST PROCEDURE
FOR
C-BAND NONCOHERENT RADAR TRANSPONDER

RANGE SAFETY GROUP

RANGE COMMANDERS COUNCIL

WHITE SANDS MISSILE RANGE
KWAJALEIN MISSILE RANGE
YUMA PROVING GROUND

PACIFIC MISSILE TEST CENTER
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receiver bandwidth, peak power output, PRF, transponder recovery time and characteristics, delay, delay variation, delay jitter, signal level, interrogating signals, rise time, RF spectrum, interrogation test, power consumption, pressure test, power turn-on surge, temperature, altitude, electrical verification test, sinusoidal vibration, random vibration, shock, equipment verification test, launch ejection shock, pyrotechnic shock, acceleration, acoustic, humidity, salt fog, dust, production acceptance tests, flight certification, preflight test.

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1.0 Introduction

C-band transponders are integral components of missile range radar instrumentation systems which provide essential range safety data. To meet critical safety requirements, it is of utmost importance to ensure the highest quality performance of such transponder systems in a variety of missile and other airborne vehicle environments. So that transponder systems will operate without failure under the severe environmental stresses typically experienced by missile and other test vehicles, it is essential to first define the environments and then to flight qualify the transponder system for those specific environments.

Because environmental stresses are not identical for all vehicles, it is not practical to define a comprehensive set of test standards. It is possible, however, to define different environmental tests and standard test procedures; that is, the intent of this document. To qualify a system for a specific range and test program, the levels for each test (vibration, shock and acceleration) must be determined and the standard procedure followed.

Qualification or flight certification of a transponder by one range does not necessarily mean that is acceptable to all ranges. Each range has its own radar and range safety responsibilities which, by their very nature, cannot be delegated.

This document defines and standardizes environmental and electrical tests required to qualify radar transponder systems for use in a specific range test vehicle. Included in this document are test procedures and requirements for design verification, range qualification, production acceptance, and pre-launch validation (pre-flight). The tests are designed to verify that the transponder performance satisfies the requirements of procurement specifications and to ensure satisfactory operation of a transponder system prior to use on range missions at national ranges. In addition, a standard data reporting format to record all test results is provided. It is not possible within the scope of this document to explain the operation of the different automated systems.

2.0 Test Equipment

The following list of electrical test equipment is required for transponder testing:

Electronic Counter	Spectrum Analyzer
Directional Coupler	VSWR Meter
Isolator	Frequency Meter
Detector Mount	Pulse Code Generator
Fixed Attenuator	Modulator
Oscilloscope	Power Supply
Power Meter	EPUT Meter
Precision Variable Attenuator	Variable Attenuator
Signal Generator	50-ohm Load Termination

3.0 **Test Setup**

A basic test setup is shown *in figure* 3-1 simplifying the equipment layout for various tests. This setup is intended as a functional block diagram for ease in explaining the procedure with the understanding that there are the different automated systems now in use.

3.1 Calibration of the Test Setup

The amount of insertion loss and pulse delay time in the test equipment between the output of the signal generator and the input to the transponder must be known to determine accurate radio frequency (RF) signal levels and signal delays. The signal level at point A in figure 3-1 can be adjusted to 0 dBm (or 1 mW) by adjusting the signal generator to a level where the signal will overcome the insertion losses. The insertion loss from the transponder point A to point B must be known to determine the transponder transmitter output power levels.

The pulse delay time is determined by measuring the delay time between point D and point A (recorded in microseconds) as read by an oscilloscope or time-interval counter. This time must be subtracted when measuring the transponder delay.

3.1.1 Insertion Loss Measurement-Signal Generator to Transponder

a. Refer to figure 3-1 for the basic setup.

b. Set the modulator to external pulse.

c. Set the pulse generator for two pulse operations and 1000 pulse pairs/sec repetition rate.

d. Turn the modulator switch of the signal generator to continuous wave (CW).

e. Connect the cable of point A to the input of the frequency meter at point C.

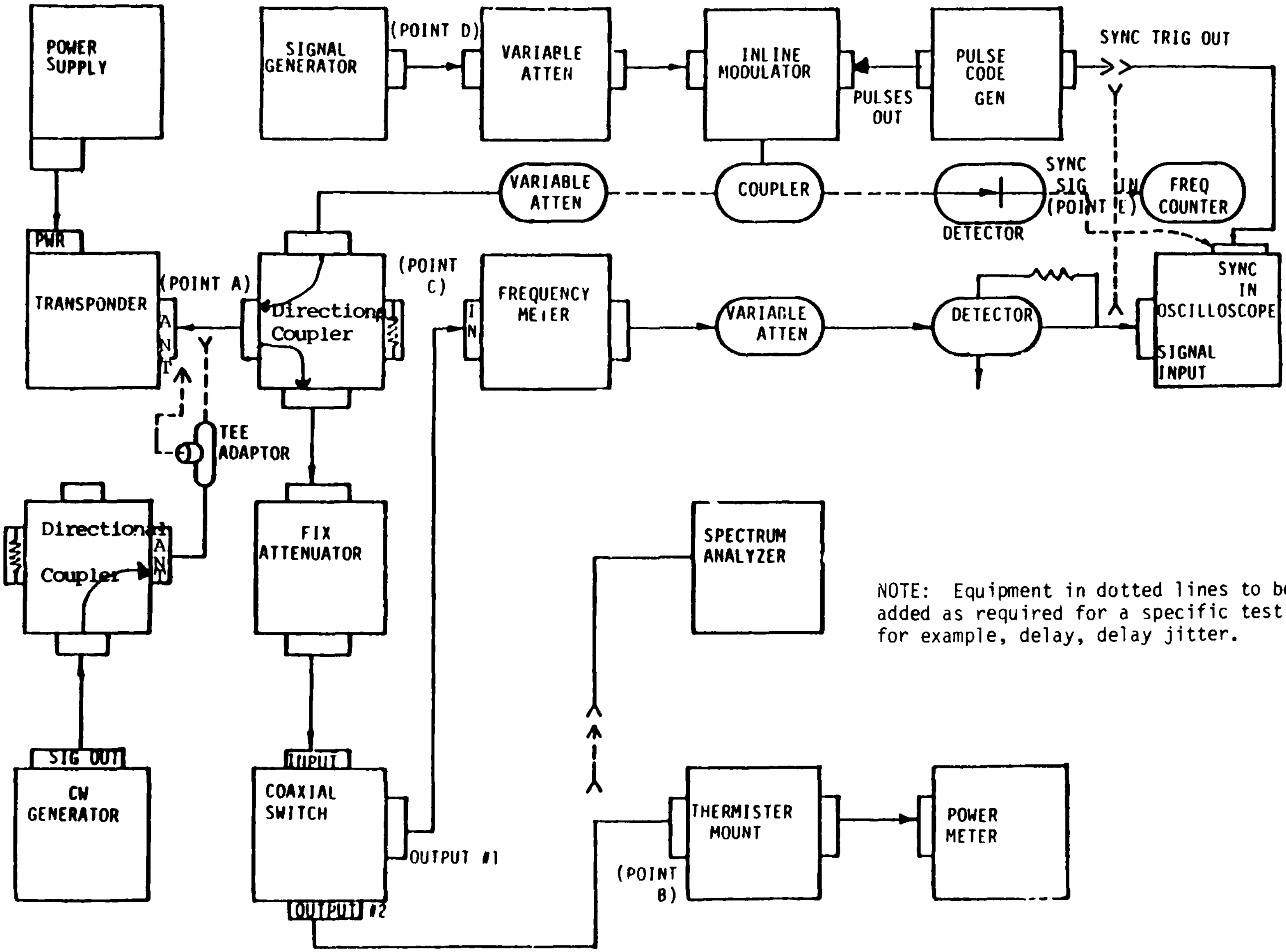
f. Set the frequency meter to 5400 MHz.

g. Adjust the power output of the signal generator for sufficient amplitude of the pulse viewed on the oscilloscope.

h. Adjust the frequency of the signal generator until the pulses seen on the scope "dip" in amplitude. If a frequency counter is used, monitor and record the digital frequency reading.

i. Detune the frequency meter and measure the rise and fall time of the signal generator RF pulse.

j. Disconnect the point A cable from the frequency meter and connect point C to the frequency meter.



NOTE: Equipment in dotted lines to be added as required for a specific test, for example, delay, delay jitter.

Figure 3-1. Test Setup

k. Connect the point A cable to the thermistor mount of the power meter.

l. Set the pin modulator for amplitude modulation (AM) operation.

m. Zero the power meter on the 1-mW scale.

n. Set the signal generator modulator switch to CW and adjust the power output for 0 dB (1 mW) as read on the power meter. Set the power set marker to 0 dBm on the signal generator attenuator dial.

3.1.2 Insertion Loss Measurement-Receiver Transmitter to Power Meter

To obtain the amount of attenuation from point A to point B in figure 3-1 for purposes of determining transmitter power output, proceed as follows:

a. Disconnect the power meter from point B and disconnect the point D cable. Connect the thermistor mount of power meter to the signal generator.

b. Set the signal generator modulator switch to OFF and zero the power meter on the +10 dB scale.

c. Set the signal generator modulator switch to CW and set the generator power output for full scale deflection on the -10 dB scale.

d. Disconnect the power meter from the signal generator and reconnect it to point B. **Do not** connect the point D cable to the signal generator.

e. Disconnect the point A cable from the transponder antenna and connect it to the RF output of the signal generator at point D.

f. Set the signal generator modulator switch to OFF.

g. Zero the power meter on the -10 dB scale.

h. Set the signal generator modulator switch to CW and take the reading on the power meter dB scale. The total insertion loss between point A and point B is the meter reading plus the -10 dB meter scale factor.

i. Repeat this procedure (subparagraphs 3.1.1a through 3.1.2h) for frequencies of 5650, 5700, 5900 MHz and the assigned frequency for specific operation.

3.2 Test List

The electrical test procedures are described in paragraph 4.1, and the environmental test procedures are described in paragraph 4.2.

3.2.1 Electrical Test. The following list contains the minimum number of electrical tests to be performed to satisfy design verification for government specifications. Selections from this list will be made for range qualification, production acceptance, and pre-launch validation as agreed upon by range personnel, range users, and test vehicle contractors. Test methods for each type are included in the test procedure part of this document.

a. Receiver sensitivity and random triggering vs. frequency.

b. Receiver sensitivity vs. input pulse width.

c. Receiver sensitivity and random triggering vs. line voltage.

d. Receiver code accept/reject.

e. Receiver code reject test 3.0 through 12.0 microseconds code.

f. Rejection of improper signals.

g. Receiver bandwidth at 3 dB.

h. Peak power output vs. pulse repetition frequency (PRF) in 500 pps steps.

i. Peak power output vs. transmitter frequency.

j. Peak power output vs. line voltage at 22, 28 and 32 Vdc.

k. Transponder recovery time and recovery characteristics.

l. Transmitter frequency vs. PFR.

m. Delay variation and delay jitter vs. signal level.

n. Delay and delay jitter vs. line voltage.

o. Recovery time vs. difference in signal level of two interrogating signals.

p. Transmitter pulse width, pulse width jitter, rise time, fall time.

q. Transmitter RF spectrum.

r. Over-interrogation test.

s. In-rush current test.

3.2.2 Environmental Test. The following list contains the minimum number of environmental tests to be performed to satisfy design verification for government specifications. Selections from this list will be made for range qualification, production acceptance,

and pre-launch validation by mutual agreement between range personnel, range users, and test vehicle contractors. Related test methods are included in the test procedure part of this document.

a. High/low temperature and altitude.

b. Humidity

c. Fungus

d. Salt fog

e. Sand dust

f. Sinusoidal vibration

g. Random vibration

h. Shock

i. Launch ejection shock

j. Pyrotechnic shock

k. Acceleration

l. Acoustic

m. Electromagnetic interference (EMI)

n. Electromagnetic compatibility.

4.0 **Test Procedures**

Allow 3 minutes warmup time after application of DC power to transponder before performing tests.

4.1 Electrical Test (room ambient)

/ / / / / / / / / / / /

CAUTION

Maintain a minimum 50-MHz separation between receiver and transmitter frequencies.

/ / / / / / / / / / / /

4.1.1 Receiver Sensitivity and Random Triggering vs. Frequency

a. Test Method.

(1) With the transponder tuned to 5400 MHz, measure the receiver sensitivity to a threshold of 99 percent response to interrogations.

(2) Turn off interrogation to the transponder and monitor for random replies not to exceed 10 pps.

(3) Repeat step 4.1.1a with transponder receiver frequencies of 5650 and 5900 MHz.

b. Criteria. Must satisfy requirements of procurement specifications.

4.1.2 Receiver Sensitivity vs. Input Pulse Width

a. Test Setup. As shown in figure 3-1.

b. Test Conditions.

(1) Transponder interrogate frequency: 5800 MHz or as required.

(2) Tranponder interrogate code: 2 pulses, 5 microseconds apart, or as required.

(3) Transponder transmitter frequency: 5700 MHz or as required.

(4) Repetition rate: 1000 pulse pairs/second or as required.

c. Test Method.

(1) Interrogate the transponder using the above conditions and interrogate pulse widths of 0.25, 0.50, and 1.0 microsecond.

(2) Record the sensitivity for each pulse width.

d. Criteria. Must satisfy the requirements of procurement specifications.

4.1.3 Receiver Sensitivity and Random Triggering vs. Line Voltage

a. Test Setup. As shown in figure 3-1.

b. Test Conditions. As shown in subparagraph 4.1.2b.

c. Test Method.

(1) Adjust the primary DC input voltage to the transponder to 27.0 ± 1 volt and interrogate with the above conditions.

(2) Repeat subparagraph 4.1.1a.

(3) Repeat this test for input line voltages of 22 + 0.5 -0 volts and 32.0 + 0 volts -0.5 volts without making any adjustments to the transponder.

d. Criteria. Must satisfy the requirements of procurement specifications.

4.1.4 Receiver Code Accept/Reject

a. Test Setup. As shown in figure 3-1.

b. Test Conditions. Same as subparagraph 4.1.2b with the exception of code which will be adjusted to 3, 5 and 12 microseconds.

c. Test Method.

(1) Adjust the interrogate signal to 0 dBm and 3 microsecond code.

(2) Set the transponder to operate at 3 microsecond code.

(3) Monitor the pulse spacing on the oscilloscope and the transponder reply PRF on the frequency counter.

(4) Decrease the spacing of the pulse code (measuring at the 50 percent points leading edge to leading edge) until a countdown

of approximately 990 pps is obtained. This is the negative accept code spacing tolerance.

(5) Increase the code spacing as above for a reply countdown of 990 pps. This spacing is the negative accept code spacing.

(6) Decrease the spacing of the pulse code as above for a count of approximately 10 pps. This spacing is the negative code reject point.

(7) Increase the spacing of the pulse code as above for a count of approximately 10 pps. This spacing is the positive code reject point.

(8) Repeat steps 4.1.4c (1) through 4.1.4c (7) for transponder codes of 5.0 and 12.0 microseconds.

d. Criteria. Must satisfy the requirements of procurement specifications.

4.1.5 Receiver Code Reject Test 3.0 through 12.0 Microseconds Code

a. Test Setup. As shown in figure 3-1.

b. Test Conditions. Same as subparagraph 4.1.2b.

c. Test Method. Apply a double pulse code spacing of 3.0 microseconds at a power level of 0 dBm. Repeat for the following codes: 4.0, 6.0, 7.0, 8.0, 9.0, 10.0, 11.0, and 12.0 microseconds.

(1) Monitor all code spacing for random replies and record results.

(2) Apply a single pulse to the receiver with a signal level of -10 dBm to +20 dBm, vary pulse width from 3.0 through 12.0 microseconds while monitoring random replies.

(3) Record random replies.

d. Criteria. Must satisfy the requirements of procurement specifications.

4.1.6 Rejection of Improper Signals

a. Test Setup. As shown in figure 3-1.

b. Test Conditions. Same as subparagraph 4.1.2b.

c. Test Method.

(1) Set the RF generator modulation to provide a CW signal.

(2) Adjust the RF signal input to the transponder to 0 dBm.

(3) Vary the frequency of the RF signal generator from 5400 to 5900 MHz.

(4) Record any increase in random triggering above 10 pps and RF frequency at which the increase occurs.

d. Criteria. Must satisfy the requirements of procurement specifications.

4.1.7 Receiver Bandwidth at 3 dB

a. Test Setup. As shown in figure 3-1.

b. Test Conditions. Same as subparagraph 4.1.2b except vary receiver frequency.

c. Test Method.

(1) Adjust the signal generator and transponder receiver to 5400 MHz. Decrease the interrogate signal level until a reply countdown of 990 pps is obtained. This level is the receiver threshold sensitivity.

(2) Increase the interrogate signal to 3 dB above the threshold level. Increase the signal generator frequency until a reply countdown of 990 pps is obtained. Measure and record the signal generator frequency at this setting. This frequency is the high side of the receiver bandwidth, F1.

(3) Decrease the interrogate frequency until the transponder reply is the normal 1000 pps. Continue to decrease the interrogate frequency until a countdown of 990 pps is obtained. Measure and record this signal generator frequency. This frequency is the low side of the bandwidth.

(4) Calculate and record the 3-dB bandwidth.

(5) Repeat this test for receiver frequencies of 5600 and 5900 MHz.

d. Criteria. Must satisfy the requirements of procurement specifications.

4.1.8 Peak Power Output vs. PRF in 500-pps Steps from 100 to 2600 pps

a. Test Setup. As shown in figure 3-1.

b. Test Conditions. Same as subparagraph 4.1.2b except PRF.

c. Test Method.

(1) Adjust input PRF in 500-pps steps from 100 to 2600 pps. With input PRF set to 100 pps, measure pulse width and average power.

(2) Calculate peak power using formula

$$\text{Peak Power} = \frac{\text{Power (average)}}{\text{PRF (Pulse Width (in microseconds))}} \times \text{Power Factor}$$

(3) Record results for each PRF specified.

d. Criteria. Must satisfy the requirements of procurement specifications.

4.1.9 Peak Power Output vs. Transmitter Frequency 5400 to 5900

/ / / / / / / / / / / /

/ **CAUTION** /

/ Maintain a minimum 50-MHz separation between receiver and transmitter frequencies. /

/ / / / / / / / / / / /

a. Test Setup. As shown in figure 3-1.

b. Test Conditions. Same as subparagraph 4.1.2b.

c. Test Method.

(1) While monitoring the frequency counter, adjust the transponder transmitter frequency to 5400 MHz.

(2) Measure, calculate and record the peak power output as in subparagraph 4.1.8c for each frequency 5400 to 5900 in 100-MHz steps.

d. Criteria. Must satisfy the requirements of procurement specifications.

4.1.10 Transponder Recovery Time and Recovery Characteristics

a. Test Setup. As shown in figure 3-1.

b. Test Conditions. Same as subparagraph 4.1.2b.

c. Test Method.

(1) Interrogate transponder with the above conditions and monitor the reply pulse on the scope.

(2) Apply a second pulse group of interrogation pulses at approximately 100-microsecond spacing from first group and slowly decrease spacing until the transponder fails to reply to the second interrogation group. Record spacing from the leading edge of the

first reply pulse to the leading edge of the second reply pulse while the second pulse is replying at approximately 10-percent countdown.

d. Criteria. Must satisfy the requirements of procurement specifications.

4.1.11 Transmitter Frequency vs. PRF

a. Test Setup. As shown in figure 3-1.

b. Test Conditions. Same as subparagraph 4.1.2b.

c. Test Method.

(1) Measure the transmitter frequency; the frequency should be 5700 ± 3 MHz at 1000 PRF or as required.

(2) Record frequency as F on data sheet.

(3) Change PFR to 160 pps; measure and record the frequency.

(4) Repeat 4.1.11c (2) for PRFs of 320, 640 and 2600 pps.

d. Criteria. Must satisfy the requirements of procurement specifications.

4.1.12 Delay, Delay Variation, and Delay Jitter vs. Signal Level

a. Test Setup. As shown in figure 3-1.

b. Test Conditions. Same as subparagraph 4.1.2b. Double pulse code, delay measurements are taken from the 50-percent amplitude point of the second interrogate pulse leading edge to the leading edge of the detected reply pulse.

c. Test Method.

(1) Using the second pulse of the interrogation, determine a time reference from the leading edge of this pulse at an input signal level of 0 dBm.

(2) Apply the interrogate pulse to the transponder and measure the time from the interrogate pulse reference to the leading edge of the reply pulse.

(3) Record this spacing as the fixed delay time.

(4) Observe the leading edge of the reply pulse and vary the level of the input signal from 0 to -65 dBm.

(5) Measure the time difference or change as the level is varied.

(6) Record this time as delay variation.

(7) Apply a -55 dBm signal level to the transponder antenna connector.

(8) Measure the peak-to-peak time jitter to the detected reply pulse leading edge.

(9) Record this time as -55 dBm jitter.

(10) Apply a -65 dBm signal to the transponder antenna connector.

(11) Measure the peak-to-peak time jitter of the detected reply pulse leading edge.

(12) Record this time as -65 dBm jitter.

d. Criteria. Must satisfy the requirements of procurement specifications.

4.1.13 Delay and Delay Jitter vs. Line Voltage 22.0 to 32.0 Volts

a. Test Setup. As shown in figure 3-1.

b. Test Conditions. Same as subparagraph 4.1.2b.

c. Test Method.

(1) Same as subparagraphs 4.1.12c (1), 4.1.12c (2) and 4.1.12c (3) with the line voltage adjusted to 22.0 ± 0.5 volts and 32.0 + 0, -0.5 volts.

(2) Measure delay at 22 volts and delay at 32 volts.

(3) Repeat subparagraphs 4.1.12c (5) and 4.1.12c (6) with line voltage adjusted to 22.0 and then 32.0 volts to measure delay jitter.

(4) Record jitter at -55 dBm and -65 dBm input levels.

d. Criteria. Must satisfy the requirements of procurement specifications.

4.1.14 Recovery Time vs. Difference in Signal of Two Interrogating Signals

a. Test Setup. As shown in figure 3-1.

b. Test Conditions. Same as subparagraph 4.1.2b.

c. Test Method.

(1) This test will require two pulse generators and two RF signal generators.

(2) Sync both pulse generators and the oscilloscope from pulse generator number 1.

(3) Adjust the pulse generators to provide identical double-pulse 5-microsecond code groups with 50-microsecond spacing between groups measuring from the leading edge of the first of each group.

(4) Adjust RF signal generator number 1 for a 0-dBm level at the transponder antenna connector.

(5) Adjust RF signal number 2 for a -65 dBm level at the transponder antenna connector.

(6) Interrogate the transponder with the above combined signals and measure the recovery time.

d. Criteria. Must satisfy the requirements of procurement specifications.

4.1.15 Transmitter Pulse Width, Pulse Width Jitter, and Rise Time

a. Test Setup. As shown in figure 3-1.

b. Test Conditions. Same as subparagraph 4.1.2b.

c. Test Method.

(1) Measure the detected reply pulse width at the 3-dB RF power points.

(2) Measure pulse width jitter by turning scope sync selector to -Int and observing the trailing edge jitter. Record this jitter as pulse width jitter.

(3) Measure pulse rise time from the 10 to 90 percent amplitude points.

(4) Measure pulse fall time from the 90 to 10 percent amplitude points.

(5) Measure and record all parameters listed above for 5400, 5650 and 5900 MHz or as specified.

d. Criteria. Must satisfy the requirements of procurement specifications.

4.1.16 Transmitter RF Spectrum

a. Test Setup. As shown in figure 3-1.

b. Test Conditions. Same as subparagraph 4.1.2b.

c. Test Method.

(1) Observe the transmitter RF spectrum on the spectrum analyzer. Measure and record the spectrum width of the main lobe at the 6-dB point.

(2) Measure and record the difference in amplitude of the peak of the first side lobe to the peak of the fundamental.

(3) Measure and record the depth of the first null measuring from the peak of the fundamental to the minimum point of the null.

d. Criteria. Must satisfy the requirements of procurement specifications.

4.1.17 Over-Interrogation Test

a. Test Setup. As shown in figure 3-1.

b. Test Conditions. Same as subparagraph 4.1.2b.

c. Test Method. Using the normal test conditions, increase the pulse generator repetition rate to 5000 pulse pairs/second. Observe the reply PRF on the counter and record as the over-interrogation rate.

d. Criteria. Must satisfy the requirements of procurement specifications.

4.1.18 Power Consumption vs. Line Voltage

a. Test Setup. As shown in figure 3-1.

b. Test Conditions. Same as subparagraph 4.1.2b.

c. Test Method.

(1) Apply an interrogation signal at a PRF of 2600 pps.

(2) Adjust input line voltage to 32.0 +0 volts, -0.5 volt.

(3) Monitor input current on the current meter.

(4) Apply an interrogation signal at 1000 pps.

(5) Adjust the input line voltage to 28 + 0.5 volts.

(6) Monitor the current on current meter.

(7) Record input current on data sheet.

(8) Repeat the test with an input voltage of 22.0 + 0.5 volts, -0 volt and interrogation rate of 640 pulse groups/second.

d. Criteria. Must satisfy the requirements of procurement specifications.

4.1.19 Pressure Test

a. Test Setup. Use clean dry air to pressurize unit to 20 psig and use a container with water deep enough to entirely submerge the unit.

(1) Pressurize the unit through air valve to 20 psig.

(2) Submerge the unit in water for a period of 20 minutes to determine if the unit leaks. There shall be no evidence of leakage after the 20-minute period.

b. Criteria. Must satisfy the requirements of procurement specifications.

4.1.20 Power Turn-On Surge

/ / / / / / / / / / / /

/ **CAUTION** /

/ The switch contacts must not bounce on closure. /

/ / / / / / / / / / / /

a. Test Setup. Connect a mechanical switch in series with the positive line from the power supply to the transponder under test.

(1) Connect the negative side of the line to the oscilloscope ground.

(2) Connect a lead from the transponder side of the switch to the oscilloscope trigger input.

(3) Clip a Tektronix P6302 current probe over the positive lead between the transponder and the switch.

(4) Connect the current probe to a Tektronix AM-503 current amplifier.

(5) Connect the output of the current amplifier to the oscilloscope vertical deflection input.

(6) Adjust the oscilloscope to single sweep; to trigger on one volt, 10 milliseconds per CM sweep; and for 10 millivolts per division vertical deflection.

(7) Adjust the AM-503 current amplifier for the oscilloscope to display approximately ten times the rated input current.

(8) Adjust the power supply to furnish the transponder under test nominal input potential.

b. Test Method.

(1) Mount a camera on the oscilloscope and optimize exposure for a single sweep.

(2) Set shutter to open, close the switch, then close the shutter, open the switch, and process the film.

(3) Calibration of the oscilloscope current probe combination may be performed by substituting known value resistors chosen to produce currents of approximately the same magnitude as the transponder in-rush surge.

c. Criteria. Must satisfy the requirements of procurement specifications.

4.2 Environmental Tests

4.2.1 Temperature-Altitude

a. Test Setup. As shown in figure 3-1 with the equipment connected to the transponder inside a temperature-altitude chamber.

b. Electrical Verification Tests. Electrical tests comprise proof cycle A and proof cycle B to verify performance before, during and after exposure of the transponder to the environmental conditions. All of the tests are required for proof cycle A. Only those tests identified with a (B) in the following list are required for proof cycle B.

- Receiver sensitivity and random triggering at one selected frequency. (B)
- Receiver bandwidth at 3 dB.
- Receiver code accept/reject.
- Transmitter frequency at one selected PRF. (B)
- Peak power output at one selected frequency. (B)
- Transmitter pulse width.
- Transponder delay at 0 dBm.

(1) Mount the transponder on an adequate heat sink and place it in the test chamber.

(2) Connect the power and RF cables from the test equipment to the transponder and perform a proof cycle.

(3) Subject the transponder to temperature and altitude environments in accordance with MIL-STD 810, method 520.0, procedure III, as defined by the procurement specification. Perform a proof cycle A at each temperature and altitude extreme.

(4) Perform proof cycle A at the completion of the temperature altitude exposures.

c. Criteria. Must satisfy the requirements of procurement specifications. An out-of-tolerance condition in any of the proof cycle tests or an anomaly during the environmental exposure will constitute a failure.

4.2.2 Sinusoidal Vibration

a. Test Setup. Same as subparagraph 4.2.1a except the transponder is mounted on a fixture attached to a vibration table.

b. Electrical Verification Tests. Same as subparagraph 4.2.1b.

(1) Mount the transponder on an adequate vibration fixture and attach it to the vibration table.

(2) Connect the power and RF cables from the test equipment to the transponder and perform proof cycle A (subparagraph 4.2.1b).

(3) Subject the transponder to sinusoidal vibration along each of three mutually perpendicular axes in accordance with MIL-STD 810, method 514.3, equipment category, levels and frequencies as defined in the procurement specification. Monitor the transponder by performing proof cycle B during the vibration.

(4) Perform proof cycle A (subparagraph 4.2.1b) at the completion of the vibration exposure.

c. Criteria. Must satisfy the requirements of procurement specifications. An out-of-tolerance condition in any of the proof cycle tests or an anomaly during the vibration exposure will constitute a failure.

4.2.3 Random Vibration

a. Test Setup. Same as subparagraph 4.2.1a.

b. Electrical Verification Tests. Same as subparagraph 4.2.1b.

(1) Mount the transponder on an adequate vibration fixture and attach it to the vibration table.

(2) Connect the power and RF cable from the test equipment to the transponder and perform proof cycle A (subparagraph 4.2.1b).

(3) Subject the transponder to random vibration along each of three mutually perpendicular axes in accordance with MIL-STD 810, method 514.3. equipment category, levels and frequencies as defined in the procurement specification. Monitor the transponder by performing proof cycle B during the vibration.

(4) Perform proof cycle A (subparagraph 4.2.1b) at the completion of the vibration.

c. Criteria. Must satisfy the requirements of procurement specifications. An out-of-tolerance condition in any of the proof cycle tests or an anomaly during the vibration exposure will constitute a failure.

4.2.4 Shock

a. Test Setup. Same as subparagraph 4.2.1a with the equipment connected to the transponder on a shock machine.

b. Equipment Verification Tests. Same as subparagraph 4.2.1b.

(1) Mount the transponder on an adequate fixture and attach to the shock machine.

(2) Connect the power and RF cables to the transponder and perform proof cycle A (subparagraph 4.2.1b).

(3) Subject the transponder to shock in each of three mutually perpendicular axes in both directions, + and -, in accordance with MIL-STD 810, method 516, procedure II. Pulse shape per figure 516-1 for flight vehicle equipment. Monitor the transponder by performing proof cycle B after each drop.

(4) Perform proof cycle A (subparagraph 4.2.1b) at the completion of the shock test.

c. Criteria. Must satisfy the requirements of procurement specifications. An out-of-tolerance condition in any of the proof cycle tests or an anomaly during the shock exposure will constitute a failure.

4.2.5 Launch Ejection Shock

As required for a specific test vehicle.

4.2.6 Pyrotechnic Shock

As required for a specific test vehicle.

4.2.7 Acceleration

a. Test Setup. Same as subparagraph 4.2.1a with the equipment connected to the transponder on centrifuge machine.

b. Electrical Verification Tests. Same as subparagraph 4.2.1b.

(1) Mount the transponder on the centrifuge machine.

(2) Connect the power and RF cables to the transponder and perform proof cycle (subparagraph 4.2.1b).

(3) Subject the transponder to acceleration stress in each of three mutually perpendicular axes in accordance with MIL-STD 810, method 513, procedure II, table 513-II, levels as specified by the procurement specification. Monitor the transponder by performing proof cycle B during the acceleration.

(4) Perform proof cycle A (4.2.1b) at the completion of the acceleration exposure.

c. Criteria. Must satisfy the requirements of procurement specifications. An out-of-tolerance condition in any of the proof cycle tests or an anomaly during the acceleration exposures will constitute a failure.

4.2.8 Acoustic

a. Test Setup. Same as subparagraph 4.2.1a with the equipment connected to the transponder in an acoustic test chamber.

b. Electrical Verification Tests. Same as subparagraph 4.2.1b.

(1) Mount the transponder in the acoustic test chamber in accordance with MIL-STD 810.

(2) Connect the power and RF cables to the transponder and perform proof cycle A (subparagraph 4.2.1b).

(3) Subject the transponder to acoustic sound pressure in accordance with MIL-STD 810, method 515, procedure II, category and levels as defined by the procurement specification. The transponder shall be operating during the exposure and will be monitored by performing proof cycle B during the sound exposure.

(4) Perform proof cycle A (subparagraph 4.2.1b) at the completion of the test.

c. Criteria. Must satisfy the requirements of procurement specifications. An out-of-tolerance condition in any of the proof cycle tests or an anomaly during the acoustic exposure will constitute a failure.

4.2.9 Humidity

a. Test Setup. Same as subparagraph 4.2.1a. The test equipment will be used for proof cycle only. The transponder will be non-operational during this test.

b. Electrical Verification Tests. Perform proof cycle A prior to exposing the transponder to humidity.

(1) Subject the transponder to humidity in accordance with MIL-STD 810, method 507, procedure II.

(2) Inspect the transponder for any sign of corrosion. Perform proof cycle A (subparagraph 4.2.1b).

c. Criteria. An out-of-tolerance condition in any of the proof cycle tests or corrosion of the transponder will constitute a failure.

4.2.10 Salt Fog

a. Test Setup. Same as subparagraph 4.2.1a. The test equipment will be used for proof cycle only. The transponder will be non-operational during this test.

b. Electrical Verification Test. Perform proof cycle A prior to exposing the transponder to salt fog environments.

(1) Subject the transponder to salt fog in accordance with MIL-STD 810, method 509, procedure I.

(2) Inspect the transponder for any sign of corrosion. Perform proof cycle A (subparagraph 4.2.1b).

c. Criteria. An out-of-tolerance condition in any of the proof cycle tests or corrosion of the transponder will constitute a failure.

4.2.11 Dust (fine sand)

a. Test Setup. Same as subparagraph 4.2.1a. The test equipment will be used for proof cycle only. The transponder will be non-operational during this test.

b. Electrical Verification Test. Perform proof cycle A prior to exposing the transponder to sand-dust environment.

(1) Subject the transponder to dust (fine sand) in accordance with MIL-STD 810, method 510, procedure I.

(2) Perform proof cycle A (subparagraph 4.2.1b).

c. Criteria. Must satisfy the inspection specified by MIL-STD 810. An out-of-tolerance condition in any of the proof cycle tests will constitute a failure.

5.0 **Production Acceptance Tests**

The acceptance test phase is intended as a quality assurance program to ensure that production hardware is of the highest quality and to prevent hardware failure in flight during range missions. The tests will include a five-minute exposure of the transponder to sinusoidal vibration in Z plane. The sine-vibration test will be the same as indicated for procurement verification. Also included is a temperature test performed as indicated for procurement verification. This test is limited only to a five-minute exposure at each temperature and altitude extreme. The tests required are as indicated in the following acceptance test data record.

ACCEPTANCE TEST DATA RECORD

CONTRACT NO. _________ MODEL NO. _________ SERIAL NO. _________ DATE ___________

5.1 Electrical Tests Part No. ________ FSN ___________ Operator _____________

5.1.1 *Receiver Frequency ________MHz ________MHz _________ Limits ________

5.1.2 Receiver Sensitivity ________dBm ________dBm _________ Limits ________

5.1.3 Random Counts ________pps ________pps _________ Limits ________

5.1.4 Receiver 3 dB Bandwidth ________MHz ________MHz _________ Limits ________

5.1.5 Code Accept/Reject (code 3, 7, and 12 microseconds)

a. Reply Rate at code -.15 microsecond _________pps _________Limits _________

b. Reply Rate at code +.15 microsecond _________pps _________Limits _________

c. Reply Rate at code -.30 microsecond _________pps _________Limits _________

d. Reply Rate at code +.30 microsecond _________pps _________Limits _________

5.1.6 Rejection of incorrect code with transponder set to 5 microsecond code:

a. Reply Rate with interrogate code of 1.0 to 4.0 microseconds _________pps.

b. Reply Rate with interrogate code of 6.0 to 12 microseconds _________pps.

5.1.7 Peak Power vs. PRF

Rep Rate		Power		
a.	100 _____________	watts	Limits	___________
b.	1000 _____________	watts	Limits	___________
c.	2600 _____________	watts	Limits	___________

5.1.8 Peak Power vs. Transmitter Frequency

a. 5400 MHz_____________ watts Limits ___________

b. 5600 MHz_____________ watts Limits ___________

c. 5900 MHz_____________ watts Limits ___________

5.1.9 Transmitter Recovery Time _______________microseconds. Limits _________

5.1.10 Delay @ 0 dBm ___________________________________.

a. Delay Variation: _____________________________ microseconds @ 5 dBm

***Data to be taken at two different frequencies.**

b. ______________________________ microseconds @ 10 dBm

c. ______________________________ microseconds @ 15 dBm

d. ______________________________ microseconds @ 20 dBm

e. ______________________________ microseconds @ 25 dBm

f. ______________________________ microseconds @ 30 dBm

g. ______________________________ microseconds @ 35 dBm

h. ______________________________ microseconds @ 40 dBm

i. ______________________________ microseconds @ 45 dBm

j. ______________________________ microseconds @ 50 dBm

k. ______________________________ microseconds @ 55 dBm

l. ______________________________ microseconds @ 60 dBm

m. ______________________________ microseconds @ 65 dBm

5.1.11 Transmitter Pulse width, Rise Time, Fall Time, vs. Transmitter Frequency:

a. *Transmitter Frequency ______MHz _______MHz _______MHz Limits ________

b. Transmitter Pulse Width ______microseconds ________ microseconds ______

______________ microseconds Limits ______________

c. Rise Time _______microseconds ________ microseconds

______________ microseconds Limits ______________

d. Fall Time _______microseconds ________ microseconds

______________ microseconds Limits ______________

5.1.12 Transmitter Spectrum vs. Frequency (5400, 5600, 5900 MHz)

Transmitter Frequency ______MHz _______MHz _______MHz Limits _________

5.1.13 Transmitter Spectrum vs. Frequency

a. Transmitter Frequency ______MHz _______MHz _______MHz Limits _________

b. 6-dB Spectrum Width ______MHz _______MHz _______MHz Limits _________

c. Side Lobe Amplitude ______dB _______dB _______dB Limits _________

5.1.14 Over-Interrogation Time ___________________pps. _______ Limits ________

***3 Frequencies 5400, 5600, 5900**

ACCEPTANCE TEST DATA SHEET

Contract # ________ **Model** ________ **Serial #** ________ **Date** ________

PROOF CYCLE	ROOM AMBIENT	VIBRATION		LOW TEMPERTURE		HIGH TEMPERATURE		LIMITS
		PRE	POST	PRE	POST	PRE	POST	
Receiver Frequency (MHz)								
Receiver Sensitivity (dBm)								
Random Trigger Rate (pps)								
Code Accept/Reject Reply Rate at Code: -0.15 microsecond								
+0.15 microsecond								
-0.30 microsecond								
+0.30 microsecond								
Transmitter Frequency (MHz)								
Transmitter Reply Rate (pps)								
Transmitter Pulsewidth (microseconds)								
Transmitter Peak Power Output (watts)								
Transponder Delay at 0 dBm (microseconds)								
Pressure Leak Test								

6.0 **Transponder Flight Certification**

The purpose of this test is to ensure that the radar transponder satisfies the original performance specification and that it will perform to this specification under the anticipated flight environments of a specific program. This test will take at least one transponder through all the anticipated flight environments such as temperature, altitude, vibration, shock, and acceleration. The electrical performance of the transponder will be evaluated during these tests. Once a transponder is environmentally qualified, all other transponders used for support of a program will require only electrical certification. The anticipated flight environments will be provided to the range by the range user. The electrical tests contained in the following data sheet will be performed before, after and/or during the environmental tests as specified.

FLIGHT CERTIFICATION

Program ________ **Transponder Model** ________ **Serial #** ________ **Date** ________

Part # ________ **FSN** ________ **Operator** ________

ELECTRICAL FUNCTIONAL	ROOM AMBIENT	VIBRATION		SHOCK	TEMPERATURE		EMI COMPATIBILITY	LIMITS
		SINE	RANDOM		LOW	HIGH		
Receiver Frequency (MHz)								
Receiver Sensitivity (dBm)								
Code Spacing (microseconds)								
Code Accept Zone (microseconds)								
Code Reject Zone (microseconds)								
Interrogate prf (pps)								
Transmitter Frequency (MHz)								
Transmitter Pulsewidth (microseconds)								
Transmitter Reply Rate (pps)								
Transmitter Peak Power (watts)								
Delay at 0 dBm (microseconds)								

FLIGHT CERTIFICATION

Program ______________ **Transponder Model** ____________ **Serial #** ______________ **Date** __________

Part # ______________ **FSN** ______________________ **Operator** ______________________________

ELECTRICAL FUNCTIONAL	ROOM AMBIENT	VIBRATION		SHOCK	TEMPERATURE		EMI COMPATIBILITY	LIMITS
		SINE	RANDOM		LOW	HIGH		
Delay Variation 0 to 65 dBm (microseconds)								
Delay in Yards								
Recovery Time (microseconds)								

ELECTRICAL FUNCTIONAL	ROOM AMBIENT	VIBRATION		SHOCK	TEMPERATURE		HIGH COMPATIBILITY	LIMITS
		SINE	RANDOM		LOW	HIGH		
Over Interrogation prf (pps)								
Transmitter Frequency Drift from Cold Start to 1 Hour Run (MHz)								
Spectrum Analysis (microseconds)								

7.0 **Preflight Test**. The transponder preflight test is an open-loop evaluation of the transponder system after it is installed in the test vehicle. The purpose of the test is to ensure that the transponder is operating to specifications in flight configuration prior to take off or launch. The test is performed using a radar simulator or laboratory test equipment.

TRANSPONDER PREFLIGHT RECORD

7.1 Mission-Program Information

a. Mission/Operation Number ______________________ Date ______________

b. UDS ______________________

c. Transponder Model __________ PN _________ Transponder SN ______________

d. Transponder Certification Due Date ______________________________

e. Preflight Scheduled Time ______________________________

f. Test Start ______________________ Test Complete ______________________

g. Radar Simulator SN and Last Calibration Date ______________________

h. Radar Station Number ______________________________

i. Type Test Vehicle ________________ Vehicle No. ______________________

7.2 Transponder Data

	Reading	Specification	Limits
a. Transponder Interrogate Frequency	____________	____________	____________
b. Receiver Sensitivity	____________	____________	____________
c. Receiver Bandwidth 3 dB	____________	____________	____________
d. Interrogate Pulse Code	____________	____________	____________
e. Interrogate Pulse Width	____________	____________	____________
f. Interrogate Repetition Rate	____________	____________	____________
g. Reply Frequency	____________	____________	____________
h. Reply Pulse Width	____________	____________	____________
i. Reply Peak Power	____________	____________	____________
j. Transponder Delay	____________	____________	____________
k. Transponder Delay Variation W/Signal Level	____________	____________	____________

	Reading	Specification	Limits
l. Transponder Antenna Radiation From All Antenna ________	____________	______________	_____________
m. RF Cable Type and Length	____________	______________	_____________
n. All RF and DC Connections Checked	____________	______________	_____________
o. Power DC: 28-Vdc Nominal			
INT _____________	____________	______________	_____________
EXT _____________	____________	______________	_____________

7.3 Radar Data

a. Power Required to Interrogate ______________________________________

b. Radar Interrogate Pulse Rise Time ________________________________

c. Radar Lock Angle: AZ ______________________ EL _____________________

d. Slant Range to Transponder ____

e. Vehicle Enclosed: Yes _______________ No __________________

f. Vehicle Position: Vertical ______________ Horizontal _______________

Signature: ____

Approval: ____

ATE

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